Expanding the Ontology of Organizational Structures of Trauma Centers and Trauma Systems

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Abstract

A knowledge gap exists regarding the impact of organizational parameters of trauma centers and patient outcomes. This is partially due to such organizational parameters being understudied. The Ontology of Organizational Structures of Trauma Centers and Trauma Systems (OOSTT) provides a controlled vocabulary to study that specific area. It is used in tools created by the TIPTOE project to provide trauma stakeholders with novel insights on role of organizational parameters and patient outcomes. This paper reports the extension of OOSTT to cover relevant patient outcome measures.

Keywords

medical ontologies, trauma centers, organizational structures, patient outcomes

1. Introduction

In the United States in 2020, trauma is the leading cause of death for individuals under the age of 45 [1]. Despite growing standardization of clinical trauma care, at Level 1 (L1) and Level 2 (L2) trauma centers, there remains significant variability in patient outcomes across trauma centers on both levels [2, 3]. We hypothesize that this variability in patient outcomes is partially created by variability in organizational parameters of the trauma centers, which is an understudied subject. The Ontology of Organizational Structures of Trauma Centers and Trauma Systems (OOSTT) is aimed to help address the knowledge gap regarding organizational structures. Its initial releases cover representation of trauma centers and trauma systems, their components, and the roles of professional and deontic roles that are part of these organizations [4]. OOSTT has been tested and validated to provide a controlled vocabulary for trauma centers and trauma systems organization [5]. It has been used to collect organizational data of trauma centers and trauma systems for the Comparative Assessment Framework of Environments of Trauma Care (CAFE) web service [6].

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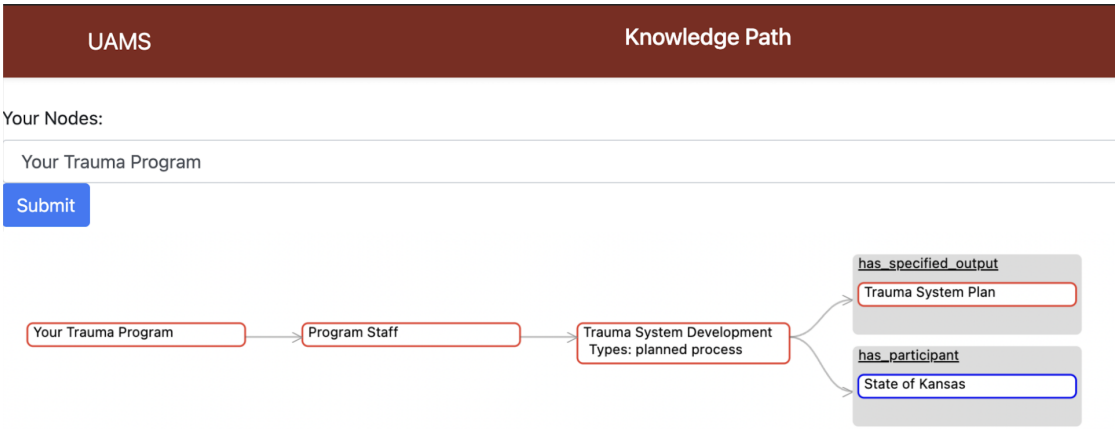

Figure 1: Screenshot of the TIPTOE Knowledge Path Explorer. Showing an example how a user can explore the knowledge graph about their trauma program.

In 2022, the second phase of the CAFE project started, and was renamed Trauma Institutional Priorities and Teams for Outcomes Efficacy (TIPTOE). The purpose of this phase is the evolution of trauma center quality improvement fostering adding scientific evidence regarding impact of organizational parameters on patient outcomes in L1 and L2 trauma centers. TIPTOE is recruiting 230 L1 and L2 trauma centers to fill in the survey about organizational parameters, similar to the CAFE web service [8], and provide their Trauma Quality Improvement Program (TQIP) data. TQIP is an initiative by the American College of Surgeons, Committee on Trauma aimed to improve the quality of care for trauma patients [7]. It collects data from trauma centers and provides feedback about performance and identifies improvements to be implemented by trauma center staff to improve outcomes [7].

One tool TIPTOE has developed is the Knowledge Path Explorer (KPE),that allows trauma center stakeholders to explore a knowledge graph that links organizational parameters of their institution to patient outcomes. The KPE graph is organized using OOSTTT. Figure 1 shows the design of the KPE pilot that we are currently reviewing with medical staff for enhancements to design and functionality. The current visual graph interface allows inspection of specific parameters of interest while also providing the added benefit of showing context of the ontological information and relationships to other related parameters. Through participatory design with medical stakeholders and center leadership, the system will evolve to accommodate a broad range of data exploration goals. In this paper, we report the extensions of OOSTT, which are necessary to cover patient outcome data; something that was not necessary to the first phase of the project.

2. Methods

2.1. OBO Foundry

The Open Biological and Biomedical Ontology Foundry (OBO Foundry) (http://obofoundry.org/) is a library of open source, community developed biological and biomedical ontologies agreeing to a set of overarching principles [8, 9]. The OBO Foundry aims at "facilitating the development, harmonization, application and sharing of ontologies (...)"[9].

2.2. OOSTT

OOSTT is a publicly available ontology that is part of the OBO Foundry and follows OBO Foundry principles. OOSTT can be accessed via http://obolibrary.org/obo/oostt.owl. Additional information and tools, e.g., an issue tracker, can be found at OOSTT's git repository: http://github.com/OOSTT/OOSTT. OOSTT uses Basic Formal Ontology [10]as its top level ontology and covers the domain of trauma center and trauma system organizational parameters. In 2022, the design principles and coverage of OOSTT have been reviewed by WRH, who was not involved in the initial OOSTT development. The adjustment and changes suggested by that review have been implemented during 2023.

2.3. OOSTT Extensions

This current ontology development step aims to provide ontological representation for TQIP data elements to enable the integration of TQIP data with data on organizational structures in the TIPTOE project and, specifically in the KPE . This extension was done using two different approaches: a) terminology-driven to broaden OOSTT coverage, b) data-driven providing representation for the 3 patient outcomes TIPTOE focuses on.

2.3.1. Terminology-driven Extension

To foster integration with trauma outcome data nationwide, the study started with definitions and labels from TQIP's data dictionary, the National Trauma Data Standard (NTDS)[11]. The project was done as a Summer Research Internship by DM. First, 20 terms from the NTDS were identified for implementation in the Web Ontology Language (OWL) and inclusion in OOSTT. These terms were picked based on priority regarding project needs. A spreadsheet was created to account for changes made to each term and its curation status.

First, the label of each term from NTSD was also reviewed for consistency with the label format suggested by [12]. Each label that did not follow the format was edited to their singular form, the expanded version of abbreviations/symbols, and in lowercase lettering. For instance, "ICD-10 INJURY DIAGNOSIS" became "international classification of diseases tenth revision injury diagnosis". Additionally, all acronyms were expanded, to prevent misunderstandings, following the OBO Foundry principle on naming[13].

There were also instances where broader terms were broken down into more specific terms. According to the NTDS database, the term "alternative home residence" represents individuals that are either homeless, living at a temporary residence, or are undocumented. We decided to

Table 1
Examples of classes imported to OOSTT using MIREOT

Source Ontology	Terms
OMRSE	patient discharge, admission process
MONDO	respiratory failure, acute respiratory distress syndrome, myocardial infarction, cardiac arrest, pulmonary embolism, stroke disorder
IDO	severe sepsis
MAXO	endotracheal intubation

discard “alternative home residence” replaced by three terms capturing its respective values: “homeless”, “temporary address”, and “undocumented immigrant”. By following these guidelines, we are preventing incorrect hierarchical structures, such as claiming that an instance of an undocumented immigrant is also a member of the class ‘alternative home residence’, once we build the OWL hierarchy. This complies with the requirement to build taxonomies on the basis that every member of the child class is also a member of the parent class[14].

Second, we reviewed the definitions of the NTDS terms and found that some of them are defined in a circular manner, viz. the label or parts thereof are used as the definition. For instance, NTDS defines the term ICD-10 INJURY DIAGNOSIS as “diagnosis related to all identified injuries”. The definition does not explicate what the words ”diagnosis” and ”injury” actually mean. Additionally, the phrase ICD-10 is addressed by the definition. We propose an alternative definition: “The international classification of diseases tenth revision injury diagnosis is an information content entity that is about an injury borne by a patient and that has an ICD code as a part”. This definition uses the next superclass (genus), ”information content entity”, and gives differentiating characteristics. Thus, the term is defined by it being a member of a specific superclass and its specific, defining characteristics, following the format suggested by OBO Foundry principles[15]. Each definition was rewritten following this format.

The revised and edited terms yielded 11 potential new ontology classes. Those were checked against OBO Foundry ontologies, to prevent duplication. None of the new classes were duplicating existing classes from OBO Foundry ontologies. Hence, they were implemented in OWL[16] using the Protege ontology editor [17]. This was done by creating a novel OWL file. This file imported BFO [10]and the Information Artifact Ontology (IAO)[18]. The resulting OWL file was merged with the latest release of OOSTT resulting in OOSTT release version 2024-01-25 (https://github.com/OOSTT/OOSTT/tree/2024-01-25).

2.3.2. Data-driven Extension

In parallel to the terminology-driven approach, we needed to extend OOSTT to cover the 3 patient outcomes the TIPTOE project focuses on:mortality, length of stay, and major complications. For major complications the representation of clinical conditions and situations was also needed. Many of the necessary classes were imported from OMRSE[19], MONDO[20], IDO[21], and MAXO[22] using a MIREOT[23] Protege Plugin. Examples of these classes are given in Table 1. In total, 36 classes were imported to OOSTT in this step. In addition, 8 classes were created newly in OOSTT: unplanned intensive care unit admission process, intensive

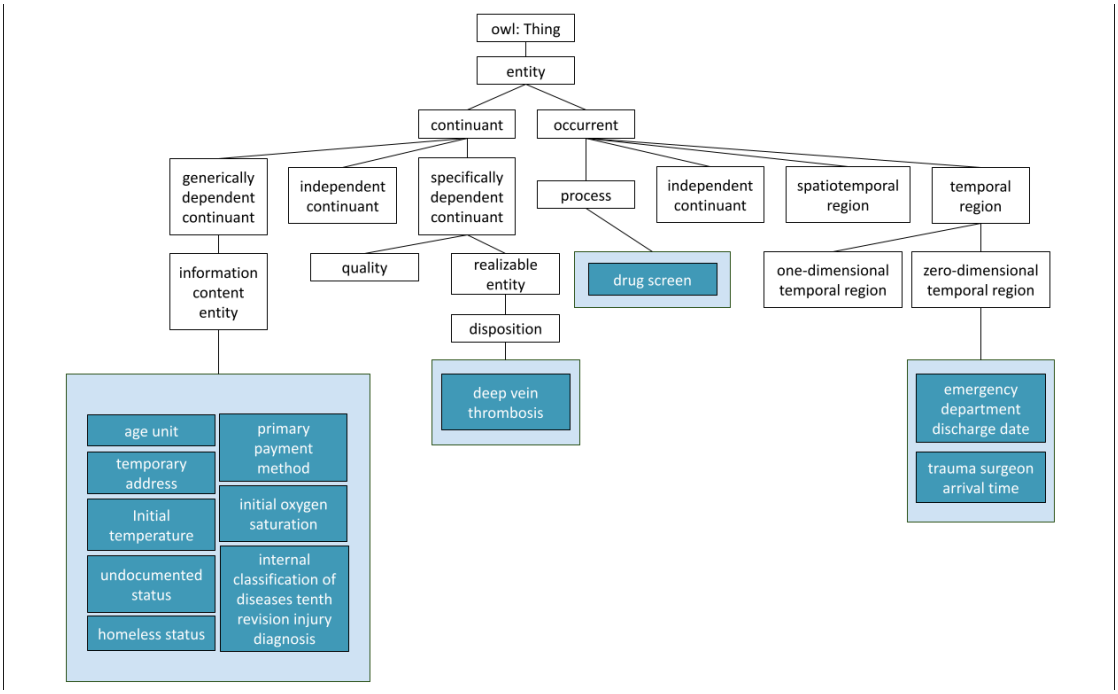

Figure 2: Visual representation of the created OWL file. BFO and IAO subclasses represented by white boxes and newly created NTDS terms categorized highlighted in blue.

care unit admission process, unplanned surgical procedure, unplanned endotracheal intubation, cardiopulmonary resuscitation, patient discharge disposition information, total intensive care unit length of stay data item.

3. Results

All terms, their NTDS definitions, and the definitions revised in accordance with the principles and practices mentioned above can be found here: https://tinyurl.com/OOSTTe. Figure 2 shows how the 11 terms implemented in OWL extend BFO. The revised definitions have been revised by KWS, our trauma surgery expert. In total, OOSTT was expanded by 55 class; 36 imported classes and 19 new classes. The OOSTT release that includes all extensions discussed in this paper can be accessed at: http://purl.obolibrary.org/obo/oostt/release/2024-01-25/oostt.owl. The ontology development described here makes these outcome patient measures available in the KPE. Due to ongoing data collection and analysis, we are testing the KPE with a virtual data set that includes instance data on patient outcomes.

The integration of extensions into the Organizational and Occupational Structure and Trajectory (OOSTT) model significantly enhances our ability to discern the nuanced effects that organizational structures and features exert on patient outcomes. This methodological advancement facilitates a novel approach to examining the intricate relationships within healthcare delivery systems. By deploying this enhanced framework, our analysis can encompass both

multispecialty and single clinical service outcomes. For instance, it enables a thorough examination of multispecialty outcomes, such as readmission rates to the Intensive Care Unit (ICU), alongside the analysis of outcomes for specific conditions, like the care pathway for isolated femur fractures. This dual perspective permits a comprehensive exploration of complex system dynamics, specifically focusing on their impact on clinical care. Through this lens, we gain a more profound understanding of the interplay between organizational structures and patient health results, providing valuable insights into potential areas for improvement.

4. Discussion

At this point, we have not yet conducted analyses to assess which features of trauma centers affect patient outcomes. As the results of those statistical analyses become available, specifically the relationships between organizational features and patient outcomes those will be added to OOSTT, too.

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